Understanding the role of glaze layer with multiple surface characterization techniques aligned by computer vision algorithms

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Motivation

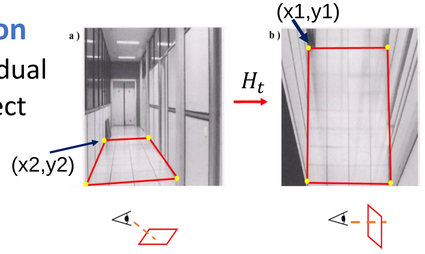
- Materials selection for low friction, low wear in high temperature applications is difficult.
- "**Glaze layer**" may form spontaneously at the contact interfaces and largely reduces friction and wear.
- Study distribution of glaze layer is challenging:
  - "Shinny, smooth, highly oxidized, superficial layer"
  - No hardware can do-it-all at high resolution.

Computer vision algorithms

- **Homography transformation**

  - translate between two individual 2D images of same planar object

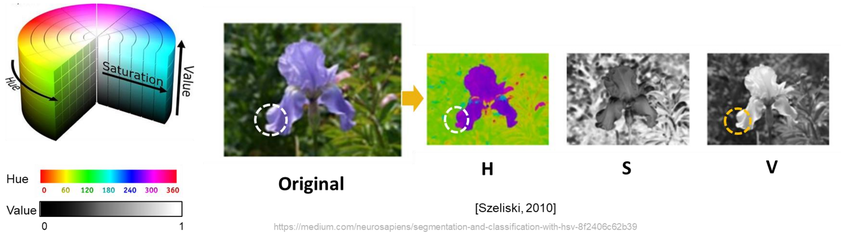
$$\begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = H_t \begin{bmatrix} x_2 \\ y_2 \\ 1 \end{bmatrix}$$



[Hartley and Zisserman, 2003]

- **HSV color space**

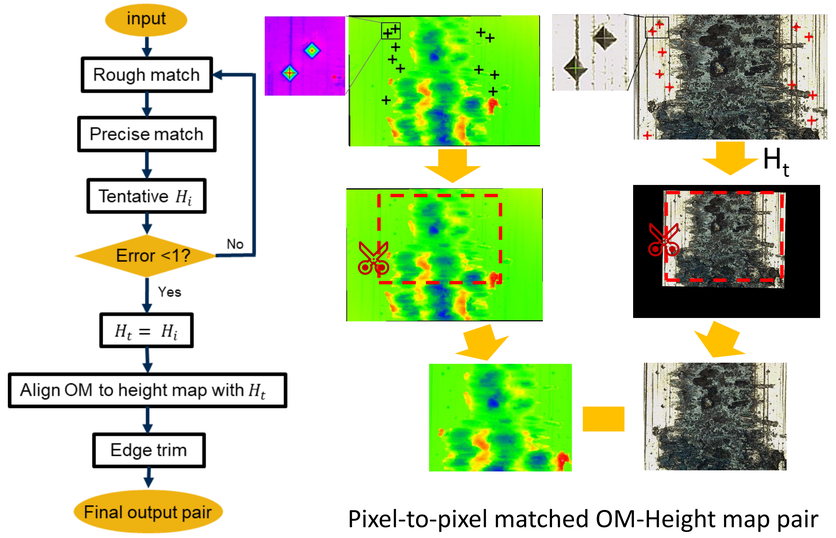
  -Segment essential information: true color[H] and brightness [V]



[Szeliski, 2010]

https://medium.com/neurosapiens/segmentation-and-classification-with-hsv-8f2406c62b39

Image alignment workflow

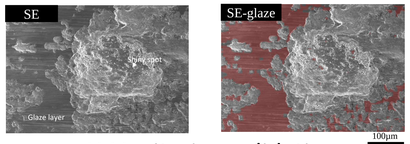


Pixel-to-pixel matched OM-Height map pair
Sub pixel error, resolution up to 0.73μm

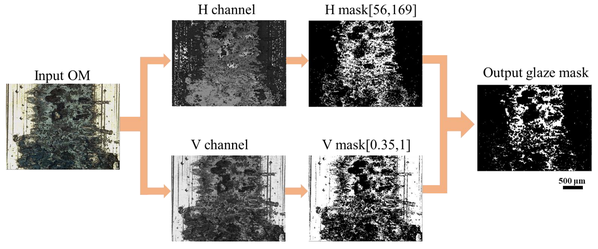
Glaze layer identification workflow

H-V criterion:

$$\begin{cases} H_{max} \geq H_i \geq H_{min} \\ V_i \geq V_{min} \end{cases}$$

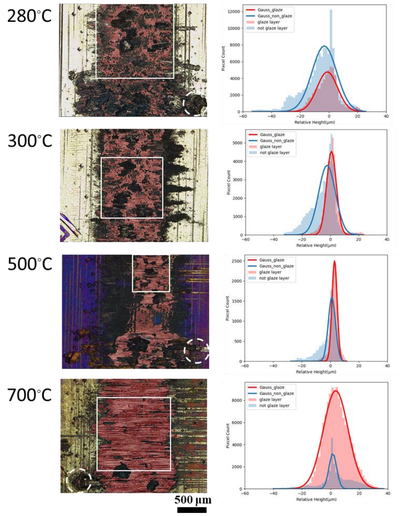


H-V criterion validation



Applications

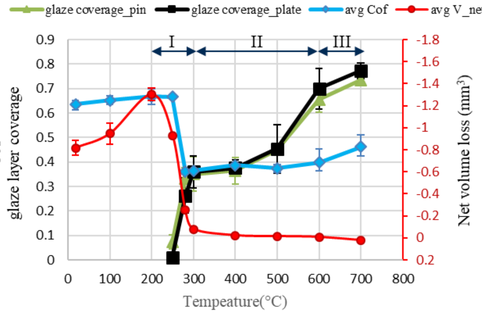
- **Height analysis:**
  - Glaze layer is always higher than non-glaze layer
  - Glaze layer is more likely to be in contact, strong evidence to sintering theory
  - May reduce real contact area



- **Coverage analysis:**

$$C_p = \frac{n_{glaze}}{n_{glaze} + n_{non-glaze}}$$

  - 36% threshold
  - Glaze coverage increase with temperature
  - 3 stages of coverage increasing



Significance

- Open-source workflow that enable multi-spectrum analysis without upgrading existing hardware, easily transferable to all other applications in academia and industry.
- Quantitative criterion that enables fast, accurate, and automatic glaze layer identification and reveal new knowledge.